CFD workshop 1: using CDF app for potential flow in Matlab

Preliminary

1. Open Matlab on your workstation (use your 1st year notes to recall Matlab)

2. Open https://uk.mathworks.com/matlabcentral/fileexchange in your browser

3. Search for the "Potential Flow" App by Ye Cheng

4. Download the Matlab application as a "potentialFlow.zip" archive. You will be asked to sign in with your MathWorks account that you have from year 1 (you can reset your forgotten MathWorks password at https://uk.mathworks.com/mwaccount/profiles/password/forgot).

5. Extract the file "potentialFlow.mlappinstall" from this archive. Double click the extracted file and confirm installation.

6. Go to Matlab Apps and open the App to see that it installed successfully

7. Watch Webinar https://uk.mathworks.com/videos/teaching-fluid-mechanics-and-heat-transfer-with-interactive-matlab-apps-81962.html
(Minutes: 13:02-19:20)

8. Go to Potential flow App and familiarize yourself with all buttons. In particular read the help page (indicated by the question mark button).

9. Try some examples.

Understanding the Maths

1. Write down what it means for a flow to be classified as potential mathematically.

2. Open and read the App code.

3. In the code there are four types of potential flows. Write down mathematical expressions for each of these potential flows. In what coordinate system are they written?

Note the source/sink flow is similar to Practical 3 Question 4 and the vortex flow is similar to course work 1.

4. In the code there is a scalar potential ϕ for each type of potential flow. Write down mathematical expressions for each ϕ . Note this app uses the convention $\vec{u} = -\overrightarrow{\nabla\phi}$.

5. The app visualises flows in the Cartesian frame. Write down how to convert from polar to cylindrical polar coordinates (See week 1 Lecture notes).

6. Derive the expression for the Cartesian velocity field (u_x, u_y) in terms of the polar velocity field (v_r, v_θ).

Hint: In Cartesian coordinates we have:

$$u_x = \frac{dx}{dt}, u_y = \frac{dy}{dt}$$

and in polar coordinates we have

$$v_r = \frac{dr}{dt}, v_\theta = r\,\frac{d\theta}{dt}$$

Exercise

A. Plot a pair of flow dipoles using Potential Flow app. Explore 2 different dipole positions.

B. Superimpose a linear velocity profile (at non zero angle with x or y axes) on the top of the dipoles.

C. Write a record of the following tasks:

a. Using sinks and sources plot a quadrupole. Describe the plots.

b. Add a vortex to the system in a. Describe the plots.

c. Explain mathematically why the vortex in this App has a potential.